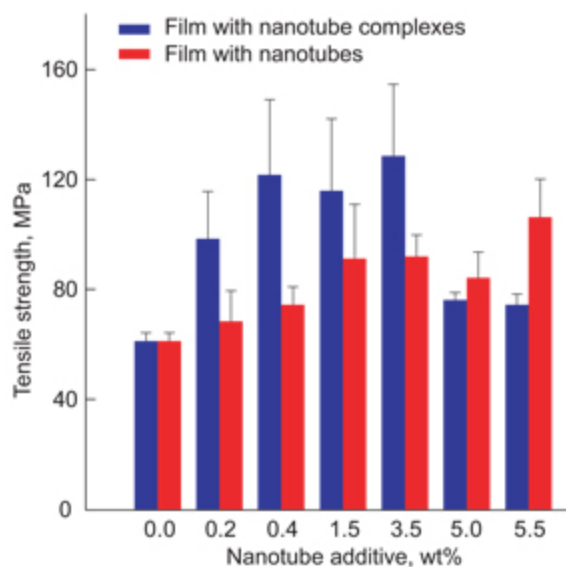


# Mechanical and Electrical Properties of a Polyimide Film Significantly Enhanced by the Addition of Single-Wall Carbon Nanotubes

Single-wall carbon nanotubes have been shown to possess a combination of outstanding mechanical, electrical, and thermal properties. The use of carbon nanotubes as an additive to improve the mechanical properties of polymers and/or enhance their thermal and electrical conductivity has been a topic of intense interest. Nanotube-modified polymeric materials could find a variety of applications in NASA missions including large-area antennas, solar arrays, and solar sails; radiation shielding materials for vehicles, habitats, and extravehicular activity suits; and multifunctional materials for vehicle structures and habitats. Use of these revolutionary materials could reduce vehicle weight significantly and improve vehicle performance and capabilities.

However, many of these applications may not be realized unless there are reliable methods to disperse nanotubes into the polymer matrix. By themselves, carbon nanotubes do not dissolve in most solvents, and they tend to agglomerate because of electrostatic (van der Waal's) interactions. Recent work at the NASA Glenn Research Center has focused on the development of molecular complexes between carbon nanotubes and large aro-matic hydrocarbons to enhance the solubility of carbon nanotubes without adversely affecting their desirable properties. This work has led to new nanotube complexes that form colloidal dispersions in organic solvents. These suspensions are stable for days at room temperature and can be easily used in the fabrication of nanotube-reinforced polymer films.

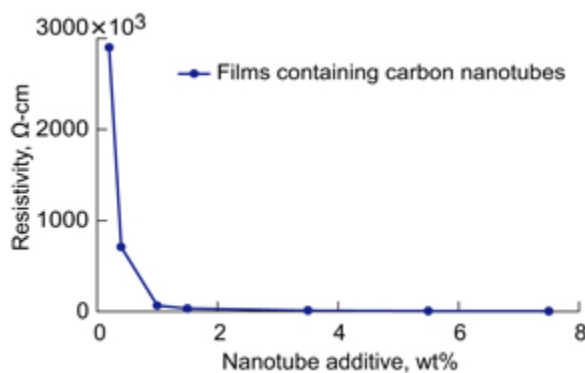
A recent study compared the effect of adding varying amounts of nanotubes and nanotube complexes on the tensile strength and electrical conductivity of a polyimide film. The bar chart shows the results.



*Effect of addition of single-wall carbon nanotubes or nanotube complexes on the tensile strength of a polyimide film.*

Addition of either nanotubes or nanotube complexes increased the tensile strength of the polyimide film. However, at low loading levels (below 3.5 wt%), addition of the nanotube complexes had a larger effect on tensile strength than the addition of the neat nanotubes did. Overall, addition of these complexes as much as doubled the tensile strength of the polyimide film.

The effect of added single-wall nanotubes on the resistivity of the same polyimide film is shown in the line graph. Addition of single-wall nanotubes resulted in as much as a 1000-fold decrease in film resistivity (this translates into 1000 times higher electrical conductivity). The effects of adding nanotube complexes on the resistivity of the polyimide are currently being measured.



*Effect of added single-wall carbon nanotubes on the resistivity of a polyimide film.*

These results demonstrate that mechanical properties and electrical conductivity of polymers can be altered significantly by the addition of small amounts (less than 10 wt%) of single-wall carbon nanotubes. Molecular complexes prepared with these nanotubes produce larger effects on mechanical property enhancement than do the neat nanotubes.

Although the resistivities of films prepared with these complexes have not been measured, we anticipate that they will follow the same trends seen for the mechanical properties. This work suggests that nanotube-doped polymers could be used as multifunctional materials in future NASA missions.

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